

WHAT IS CLAIMED IS:

1. A surgical instrument for tissue fixation comprising:
a handpiece constructed to be held by a surgeon during a fixation procedure;
5 a cannulated tube defining a lumen, mounted on the handpiece;
a delivery device, constructed to be mounted on the handpiece, for delivering a
flowable material to an opening in bone; and
a suture control device for delivering a suture material from a supply to a
distal end of the cannulated tube.
- 10 2. The surgical instrument of claim 1 wherein the suture control device is
constructed to control the tension applied to a free end of the suture.
3. The surgical instrument of claim 1 or 2 wherein the supply of suture
15 material is disposed within the handpiece.
4. The surgical instrument of claim 1 wherein said delivery device comprises
a heating element for heating said material to a flowable state.
- 20 5. The surgical instrument of claim 4 wherein said delivery device further
comprises a reservoir containing a supply of the flowable material, and said heating
element is constructed to deliver heat to at least a portion of the reservoir.
6. The surgical instrument of claim 4 wherein the heating element is
25 positioned adjacent at least a portion of the reservoir.
7. The surgical instrument of claim 4 or 5 wherein said delivery device further
comprises a delivery tube in communication with the reservoir, the delivery tube
being constructed to be disposed within the cannulated tube when the delivery device
30 is mounted on the handpiece.

8. The surgical instrument of claim 7 wherein the heating element is constructed to deliver heat to the delivery tube.

9. The surgical instrument of claim 8 wherein the heating element includes a terminal portion, adjacent a distal end of the delivery tube, which can be turned off while heat is being delivered to the remainder of the heating element, so as to allow the flowable material at the distal end of the delivery tube to solidify and shut off flow from the delivery tube.

10. The surgical instrument of claim 4 wherein said heating element comprises an elongated member having a tip, the tip having an area to which heat can be delivered to melt the pellet.

11. The surgical instrument of claim 10 wherein said delivery device further comprises a plunger tube constructed to be disposed within the cannulated tube when the delivery device is mounted on the handpiece, and the elongated member is constructed to be inserted through the plunger tube.

12. The surgical instrument of claim 11, wherein said delivery device further comprises a mechanism for moving said plunger tube between an extended position and a retracted position.

13. The surgical instrument of claim 10, 11 or 12 wherein said delivery device further comprises a mechanism for moving said elongated member between an extended position and a retracted position.

14. The surgical instrument of claim 13 wherein the mechanisms for moving the plunger tube and elongated member can be simultaneously activated by the surgeon, and operate counter to one another.

15. The surgical instrument of any of claims 4 or 7-10 wherein said heating element comprises a metal tube and, within the tube, an insulated current-carrying

wire, the wire and tube being joined at a distal end to form a circuit, and the metal tube including a first portion having a relatively low resistance and a second, distal portion having a relatively higher resistance.

5 16. The surgical instrument of any of the preceding claims wherein said delivery device comprises an elongated nozzle having a distal end constructed to receive a portion of suture, and a mechanism constructed to extend the nozzle out of the distal end of the cannulated tube to push the portion of the suture into the opening and to retract the nozzle after delivery of the suture.

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 17. The surgical instrument of claim 16 wherein said elongated nozzle is cannulated to provide a path for delivery of the flowable material to the opening.

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 18. The surgical instrument of claim 7 wherein, prior to initial use of the surgical instrument, the delivery tube contains a supply of the flowable material.

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 19. The surgical instrument of any of the preceding claims wherein said suture control device comprises nested tubes, surrounding the cannulated tube, which define a path for the suture from the supply to the distal end.

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 20. The surgical instrument of claim 19 wherein said nested tubes include an outer tube, and a middle tube disposed between the outer tube and the cannulated tube, and the path is defined by a groove extending longitudinally along the length of the middle tube.

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 21. The surgical instrument of any of the preceding claims wherein said suture control device comprises a suture lock, actuatable by the surgeon, to hold the suture in place at the distal end of the cannulated tube.

 22. The surgical instrument of any of the preceding claims wherein said suture control device comprises a suture displacement device for controlling the position of the suture at the distal end.

23. The surgical instrument of any of the preceding claims wherein said suture control device comprises a tensioning device for maintaining tension on the suture.

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24. The surgical instrument of claim 23 wherein the tensioning device is constructed to tighten a stitch formed with the suture.

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25. The surgical instrument of claim 23 or 24 wherein the tensioning device comprises a spring mechanism.

26. The surgical instrument of claim 23, 24 or 25 wherein said tensioning device is constructed to be manually actuated by the surgeon.

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27. The surgical instrument of any of the preceding claims wherein said surgical instrument is constructed to allow the surgeon to perform a complete fixation procedure at a surgical site without removing the cannulated tube from the surgical site.

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28. A surgical instrument for tissue fixation comprising:
a handpiece constructed to be held by a surgeon during a fixation procedure;
a cannulated tube defining a lumen, mounted on the handpiece; and
a delivery device for delivering a flowable material through the lumen to an opening in bone, the delivery device comprising a heating element for heating said material to a flowable state, the heating element being constructed to heat the material after the material has been delivered, in a non-flowable state, to the opening.

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29. A surgical instrument for tissue fixation comprising:
a handpiece constructed to be held by a surgeon during a fixation procedure;
a cannulated tube defining a lumen, mounted on the handpiece, the cannulated tube including a tip portion configured to receive and carry a rigid suture carrying device; and

a heating device, disposed within the cannulated tube.

5 30. The surgical instrument of claim 29, wherein the tip portion includes a
keying feature configured to restrict rotation of the suture carrying device within the
tip.

10 31. The surgical instrument of claim 29 or 30 wherein the tip portion includes
depressions in an outer surface of the tip portion, the depressions being configured to
receive a suture carried by the suture carrying device.

15 32. The surgical instrument of any of claims 29-31 further comprising a
portion of the flowable material, in a non-liquid state, disposed within the cannulated
tube.

20 33. The surgical instrument of claim 32 wherein said portion of flowable
material comprises a polymer pellet.

25 34. The surgical instrument of claim 32 or 33 wherein said portion of
flowable material is disposed adjacent the tip of the cannulated tube.

30 35. The surgical instrument of any of claims 29-34 wherein the heating device
comprises a flexible circuit.

35 36. The surgical instrument of any of claims 29-35 wherein the heating device
comprises a thermistor.

40 37. The surgical instrument of claim 35 wherein the heating device comprises
a thermally conductive tube along which the flexible circuit is positioned.

45 38. The surgical instrument of any of claims 29-37 wherein the cannulated
tube comprises an insulating tube surrounding said heating device.

39. The surgical instrument of any of claims 29-38 wherein the heating device comprises a pair of thermistors disposed in series.

40. The surgical instrument of claim 39 further comprising electronics
5 configured to compare signals received from the thermistors and to shut off power to the heating device if a predetermined difference between the signals is exceeded.

41. The surgical instrument of any of claims 29-40 wherein the surgical instrument further comprises the suture carrying device.

10 42. The surgical instrument of claim 41 wherein the suture carrying device comprises an eyelet or a groove configured to receive a portion of a suture.

15 43. The surgical instrument of claim 41 or 42 wherein the suture carrying device is generally cylindrical and comprises one or more circumferential ridges.

44. The surgical instrument of any of claims 41-43 wherein the suture carrying device includes a pair of wings extending radially from a distal end of the suture carrying device.

20 45. A method of securing a tissue to bone, comprising:
forming an opening in the bone at a first location,
delivering a flowable material, in a non-liquid state, and a suture to said
opening,
25 heating the flowable material, in the opening, to cause the material to flow,
and
allowing the flowable material to at least partially solidify and secure a portion
of the suture in the opening.

30 46. The method of claim 45 further comprising:
drawing a free portion of the suture that extends from the secured portion
across the soft tissue to a second location,

forming a second opening in the bone at the second location,
delivering a flowable material, in a non-flowable state, and a portion of the
suture to said second opening,

5 heating the flowable material, in the second opening, to cause the material to
flow, and

allowing the flowable material to at least partially solidify, the suture defining
a stitch between the first and second locations.

10 47. The method of claim 46 further comprising repeating the drawing,
forming, delivering and allowing steps at subsequent locations to form a line of
connected stitches.

48. The method of claim 45, 46 or 47 further comprising feeding the suture as
a continuous length from a supply of suture material.

15 49. The method of claim 46 or 47 further comprising, between the drawing
and delivering steps, tensioning the suture that extends across the soft tissue to the
second location.

20 50. A method of securing soft tissue to bone comprising:
coupling a suture to the soft tissue so that a portion of the suture extends from
the soft tissue;

forming an opening in the bone;
mounting the extending portion of the suture on a suture carrying device;
25 inserting the suture carrying device into the opening;
delivering a flowable material, in a liquid state, to the opening; and
allowing the flowable material to at least partially solidify to secure the suture
and suture carrying device in the opening.

30 51. The method of claim 50 wherein the suture carrying device is formed of a
non-metallic material.

52. The method of claim 51 wherein the suture carrying device comprises a resorbable polymer.

53. The method of claim 50 wherein the suture carrying device includes an eyelet, and the mounting step includes threading the suture through the eyelet.

54. The method of claim 50 wherein the suture carrying device includes a groove at a distal end of the suture carrying device, and the mounting step includes seating the suture in the groove.

55. The method of claim 50 further comprising seating the suture carrying device in the opening.

56. The method of any of claims 50-55 further comprising, between the inserting and delivering steps, tensioning the suture.

57. The method of claim 56 wherein the tensioning step comprises manually tensioning the suture.

58. The method of any of claims 50-57 wherein the inserting step comprises mounting the suture carrying device at an end of a cannulated tube, and inserting the tube into the opening.

59. The method of any of claims 50-58 further comprising providing the flowable material in a non-liquid state and heating the material to cause it to flow.

60. The method of claim 59 wherein the heating step comprises delivering power to a heating element positioned adjacent the flowable material.

61. The method of 58 wherein the heating element and flowable material are disposed in the cannulated tube on which the suture carrying device is mounted.